A Dissertation on

SURGICAL OUTCOME OF MUSCULOSKELETAL TUMORS OF PELVIS

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BONAFIDE CERTIFICATE

This is to Certify that **Dr.VIMALAKANNAN.M,** bonafide student of M.Ch. Surgical Oncology. (July 2006 to August 2009) in the Department of Surgical Oncology, Government Royapettah Hospital, Chennai - 600 014 has done this dissertation on "**SURGICAL OUTCOME OF MUSCULOSKELETAL TUMORS OF PELVIS"** under my guidance and supervision in partial fulfillment of the regulations laid down by The Tamilnadu Dr. M.G.R. Medical University, Chennai for M.Ch. Surgical Oncology Examination to be held in August 2009.

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CONTENTS

INTRODUCTION

The bony pelvis and its enveloping soft tissues are a common site for bone and soft-tissue tumors. Five percent of primary malignant bone tumors involve the pelvis. Osteosarcoma in adolescents, Ewing's sarcoma in children and chondrosarcoma in adults are the most common primary sarcomas in this location. More commonly, though, neoplasms involving the pelvis occur as a result of metastatic spread from the breast, lung, prostate, kidney or thyroid.

Until the late 1970s most pelvic tumors were treated with External hemipelvectomy, a procedure that was associated with a significant percentage of complications and a dismal functional and psychological outcome.

The 1st successful hemipelvectomy was reported by Charles Girard in 1895, for a recurrent osteosarcoma.

With the advent of more accurate imaging modalities, newer chemotherapeutic agents, use of neoadjuvant chemotherapy, improved resection techniques, and prosthetic reconstruction, limb-

sparing procedures are now performed in the majority of these cases.

Sacral tumors comprise a heterogeneous group of neoplasms ranging from benign, benign aggressive, malignant, and metastatic in origin. Patients presenting with sacral neoplasm range in age from very young with teratomas to very elderly with metastatic disease.

In 1948, Bowers' described a patient with an aggressive hypervascular pulsatile giant cell tumor of the sacrum. An initial posterior approach to the lesion was abandoned because of severe bleeding. He concluded that the vascularity was not provided by the middle and lateral sacral vessels as believed, but more likely by both the common and internal iliac vessels. He proceeded with a second two-staged, carefully thought out procedure two weeks later.

The lesion was first approached anteriorly through a transperitoneal left rectus incision where a pulsatile mass could be palpated behind the rectosigmoid. Mobilization and umbilical tape occlusion of both common iliac vessels ceased pulsations within the mass. Both internal iliac vessels were hypertrophied and were found

to enter into the mass and were ligated and transected while the umbilical tapes around both common iliac vessels remained in place. Patient turned to the prone position. The previous longitudinal posterior sacral incision performed 2 weeks earlier was reopened and the amputation through S2 was completed, retaining only the first sacral nerve roots bilaterally. The wound was drained and closed and the patient then turned supine once again. The wound was reopened and the umbilical tapes removed after 2 hours and 45 minutes. Both common iliac and femoral pulses returned to normal without complication.

MacCarty et al described their early surgical experience at the Mayo Clinic for management of sacral tumors in 1952. They preferred a single posterior approach with some lesions extending up to S1.

In the same year, Hays reported a 2.5-year follow-up of a patient initially managed with radiotherapy for giant cell tumor, then 6 weeks later with sacral amputation including the rectum, and preserving the first sacral nerve roots. Localio et al also described their experience with a two-position procedure for surgical

management of Chordoma in 1967.

In 1978, Stener and Gunterberg described in detail the currently accepted principles and technique of sacral amputation supported by a report of their clinical experience. The surgical principles and techniques described by them remains the standard by which other reports on terminal resection of the sacrum are judged.

Extensive pelvic surgeries are highly demanding because of the irregular and complex shape of the bony pelvis, numerous muscle attachments, and the proximity of major blood vessels, nerves, and visceral organs. Given the complexity of the anatomy and the use of adjuvant therapies that require an uncomplicated and expedient postoperative recovery, osseous pelvic resections remain one of the greatest surgical challenges.

AIM OF THE STUDY

1) To analyze the surgical management of musculoskeletal tumors in pelvis

2) To analyze the morbidity & mortality associated with the management of musculoskeletal tumors in pelvis

3) To analyze the oncological & functional outcome of musculoskeletal tumors in pelvis and compare with that of literature

LITERATURE REVIEW

SACRAL TUMORS

Most common primary sacral tumors are Chordoma, giant cell tumor, chondrosarcoma and plasmocytoma. Secondary infiltration of sacrum from carcinoma rectum and retroperitoneal tumor can

occur. Most common tumors requiring sacrectomy are primary sacral tumors and rectal carcinoma infiltrating the sacrum.

Characteristically, the primary tumors progress slowly to involve adjacent structures. Eventually, the sacral nerve roots coursing through the sacrum are invaded, which then cease to function.

The symptoms produced by these tumors are often vague, ranging from local pain to ill-defined lower lumbar pain associated with radicular symptoms commonly confused with the more common lower lumbar back and nerve root compression syndromes. The symptoms, however, tend to involve both lower extremities and are only late to produce the commonly suspected bowel and bladder dysfunction.

EVOLUTION OF SACRECTOMY:

Attempts to resect primary and metastatic lesions of the sacrum have intrigued surgeons for years, as is evident from numerous reports. Sacrectomy was performed by many surgeons like

Bowers in 1948, MacCarty et al (Mayo clinic) in 1952. The technique of two position procedure was popularized by Hays et al in 1952 and Localio during 1967.

In 1978, Stener and Gunterberg described the currently accepted principles and technique of sacral amputation. The surgical principles and techniques described by them remains the standard by which other reports on sacral resection are judged. Wanebo et al described a two-stage approach, beginning with an anterior procedure, followed by a posterior procedure after 1 or 2 days.

SACRECTOMY:

Better understanding of the sacral anatomy and biomechanics of lumbosacropelvic region is an important factor for a successful surgical and functional outcome. At present sacrectomy requires team work, incorporating surgical oncologist, neurosurgeon, plastic surgeon, physiotherapist and oncological nurse for a better surgical and functional outcome. Preoperative counseling with the patient and relatives about the nature surgery, long duration of immobility,

functional and surgical outcomes will have a better psychological impact and co-operation.

Preoperative imaging with plain X-ray pelvis AP view, CT scan abdomen and pelvis and/or MRI is essential for planning. Involvement of L-5 spine, extensive side wall involvement, distant metastatic disease and poor general condition negate surgery. Involvement of rectum necessitates enbloc resection and planning for colostomy also. So, meticulous bowel preparation is advisable preoperatively along with perioperative antibiotics.

Sacral resection presents a formidable challenge due to the following factors: (1) Technical complexity and difficulty often requiring combined anterior transabdominal and posterior lumbosacral approaches; (2) uncertainties or difficult decisions regarding loss of anorectal and urogenital function and control. (3) Questions regarding weight-bearing stability of retained sacroiliac postural support.

Approaches for sacrectomy:

Various approaches like anterior (transabdominal or retroperitoneal), posterior that involves sacral laminectomy,

sequential anterior and posterior (Bowers), synchronous abdominolateral (Localio) with lateral decubitus position, sequential anterior and posterior with myocutaneous flap (Stener and gunterburg) and perineal approach are described for sacrectomy. Wanebo et al described a two-stage approach, beginning with an anterior procedure, followed by a posterior procedure after 1 or 2 days.

Sequential anterior and posterior approach which is indicated in tumors with anterior extension and significant involvement of S1 and S2 segment is commonly used. Tumors below sacro-iliac joint can be approached posteriorly.

The major advantages of the posterior transsacral approach are its familiarity, wide access to the intraspinal and intradural compartments, and clear differentiation between tumor and neural tissue. It is the procedure of choice for the removal of intraspinal tumors with little or no presacral extension. Incisional biopsy or intralesional curettage of sacral body tumors is also easily performed posteriorly. Any significant presacral extension is not adequately exposed for marginal resection from this approach and will require either a staged or simultaneous anterior

procedure.

Localio described the synchronous abdominolateral approach in which the patient is placed in lateral decubitus position which gives both anterior and posterior exposure. There is no need for patient repositioning and less blood loss in this approach but exposure is limited and the efforts at mechanical stabilization and soft tissue reconstruction are complicated. This approach allows simultaneous unilateral ventral and dorsal exposure of the sacroiliac joint. It is suited for en - bloc resection of malignant tumors such as chondrosarcoma, osteosarcoma, and giant cell tumor, which cross the sacroiliac joint to involve both the lateral sacral ala and medial iliac wing.

The abdominosacral approach is the most versatile and widely employed of the combined exposures. With anterior approach, internal iliac vessels are ligated; common iliac and external iliac vessels are isolated and safeguarded. Rectum is dissected away from sacrum. So, chances of vessel injury, blood loss and rectal injury are reduced.

Omental flap transposition is possible with this approach. This approach is mandatory in patients requiring rectal resection. With

posterior approach, sacral and lumbar laminectomy is done and dural sac is carefully ligated to prevent CSF leakage and potential development of meningitis. But patient needs repositioning.

Low and High Sacrectomy:

The level of amputation, if possible, should be one sacral segment above the most rostrally involved segment as determined by preoperative imaging. Low sacrectomy (S3 or below) is relatively simple because the osteotomy is performed below the sacroiliac joint. It is most easily performed through the sacroperineal route, although more complicated cases, such as those with rectal involvement or operation for recurrent tumor, may require an abdominosacral exposure. Because the S3 nerve roots can usually be spared with low sacrectomy, urogenital and anorectal function can be preserved.

Progressively higher sacrectomy presents proportionally greater risks of morbidity. Blood loss, particularly during osteotomy of the sacrum and ilium, can be profuse and the large dead space left by the resected specimen may result in significant wound complications. Since high sacrectomy requires amputation of the

dural sac, these complications are compounded if the thecal closure is not watertight.

Preservation of S2, at least unilaterally, will often preserve voluntary uroanal sphincter control. Preservation of the S2 root should always be attempted, but not at the expense of violating the tumor margin. Lower limb function is only minimally affected with even total sacral root division but may be significantly impaired if the nearby lumbosacral trunk, gluteal, or sciatic nerves are injured during the resection.

Spino-pelvic reconstruction:

Subtotal resection of the sacrum caudal to the midportion of the S-1 vertebral body does not destabilize the pelvis. Total sacrectomy requires reconstruction of the pelvic ring plus establishment of a bilateral union between the lumbar spine and iliac bone.

Structurally, preserving the upper one half of the body of SI will retain sufficient bone and continuity of the obliquely positioned sacroiliac joint to permit immediate unprotected weight bearing. Resections including the entire body of S1 and preserving only the L5

nerve root will require posterior pedicle instrumentation with fixation to both iliac crests and additional bone grafts.

These patients should be either immobilized or limited to bed or chair activities until sufficient bone healing is present to permit weight bearing. Sacral rim stability is maintained if the resection line can be kept in the lower one half of the S1 vertebra. Fifty percent of S1 should be preserved so long as a tumor-free margin is maintained.

Reconstruction has been described by various methods like Galveston reconstruction system, modified Galveston reconstruction system, sacral bar and compression rods, Harrington compression plates, posterior and anterior instrumentations, triangular frame reconstruction etc.

Management of sacral defect after sacrectomy:

Most patients developed wound problems like dehiscence and flap necrosis. This is due to proximity to the anus, extensive resection creating large defects, ligation of internal iliac vessels and suturing with tension. Rectum may be exposed after wound dehiscence which may be avoided by covering the rectum with

omentum and use of flaps. Meticulous hemostasis, obliteration of dead space, and prophylactic antibiotics will help prevent infection.

Reconstruction of the soft tissue defect after sacrectomy has been done with Transabdominal Vertical Rectus Abdominis Myocutaneous Flap (VRAM flap), Gluteal advancement flap or free flaps.

In our series, Gluteal advancement flap was done which significantly reduced the post operative wound dehiscence & morbidity.

HEMIPELVECTOMY

In spite of increasingly effective chemotherapy and advances in limb-sparing surgery around the pelvis and hip, hindquarter amputation (hemipelvectomy) often remains the optimal surgical treatment for primary tumors of the upper thigh, hip, or pelvis. Hemipelvectomy may also be life-saving for patients with massive pelvic trauma or uncontrollable sepsis of the lower extremity, and it can provide significant palliation of uncontrollable metastatic lesions of the extremity.

The terms "hindquarter" amputation and "hemipelvectomy" are often used interchangeably to refer to any amputation performed through the pelvis. Older terms used to describe this same procedure include interpelviabdominal or interinnomino-abdominal amputation.

The advent of limb-sparing pelvic resections has necessitated a distinction between internal and external hemipelvectomy, depending on whether preservation of the ipsilateral limb is performed. Confusion caused by the term "internal hemipelvectomy" can be avoided by use of a standardized classification for pelvic resection.

Sugarbaker and others have shown the utility of a myocutaneous pedicle flap based upon the femoral vessels and anterior compartment of the thigh for closure of the wound in patients with tumor involving the posterior buttock structures. This procedure has been termed an "***anterior flap hemipelvectomy***", to distinguish it from the more common "***posterior flap hemipelvectomy***". Anterior flap hemipelvectomy is indicated for

tumors that involve the buttock and for selected patients in whom a well-vascularized flap is required for coverage.

There are subtypes of the posterior flap hemipelvectomy. The term "***classic hemipelvectomy***" is used to refer to amputation of the pelvic ring via disarticulation of the pubic symphysis and the sacroiliac joint (SI), division of the common iliac vessels, and closure with a posterior fasciocutaneous flap.

Classic hemipelvectomy is typically necessary for large tumors that arise within the pelvis.

"***Modified hemipelvectomy***" refers to a procedure that preserves the hypogastric (internal iliac) vessels and the inferior gluteal vessels supplying the gluteus maximus, permitting creation of a vascularized myocutaneous posterior flap for wound closure. This term also describes any and all variations from the classic operation, including resection through the iliac wing or contralateral pubic rami. Modified hemipelvectomy is most commonly performed for tumors involving the thigh and/or hip, when a limb-sparing alternative is contraindicated.

"*Extended hemipelvectomy*" refers to a resection of the hemipelvis through the sacral ala and neural foramina, thereby extending the margin for tumors that approach or involve the Sacro Iliac joint.

Regardless of the type of flap created for closure, the term "*compound hemipelvectomy*" is used to describe resection of contiguous visceral structures such as bladder, rectum, prostate, or uterus. (Patients suspected of having tumor extending into viscera, or an extremely large tumor filling the pelvic fossa, can be approached through an intraperitoneal incision.)

Anterior Flap Hemipelvectomy:

The anterior flap hemipelvectomy is a modified version of the classical posterior flap hemipelvectomy. Instead of utilizing the traditional posterior skin flap of the gluteal region, a myocutaneous flap from the anterior thigh is used to close the peritoneum following amputation through the sacroiliac joint and the pubic symphysis.

This modification has permitted the treatment of difficult buttock and pelvic tumors where the posterior flap was involved and/or contaminated by tumor. This technique offers patients,

initially thought to be incurable by standard technique, a good oncological procedure.

The anterior myocutaneous flap consists of a portion or the entire quadriceps muscle group on its vascular pedicle, the superficial femoral artery. This flap covers the entire peritoneal surface and generally heals with minimal problems.

Patients with extensive soft-tissue sarcomas of the buttock or bone sarcomas of the pelvis that extend posteriorly, once thought to be incurable by standard posterior flap hemipelvectomy, can often be treated with an anterior flap hemipelvectomy.

The procedure, which originally entailed use of an anterior skin flap raised off of a portion of the superficial femoral vessels, was later modified to include a full-thickness myocutaneous flap raised from the anterior thigh. This procedure may also be indicated following failed attempts at limb-sparing surgery, as well as for patients with nononcologic indications for amputation (e.g. uncontrollable sepsis from sacral or trochanteric osteomyelitis).

The major advantage of anterior flap hemipelvectomy is the creation of a large vascularized myocutaneous flap that is ideal for

closure of significant posterior defects. As much of the anterior thigh compartment may be saved as needed, depending on the size of the defect being closed.

As always, careful patient selection is critical in ensuring that an acceptable outcome is achieved. For example, elderly patients and diabetics with silent atherosclerotic disease of femoral vessels must be carefully evaluated with preoperative angiography. The suitability of this procedure may also be limited by the anatomic location of the tumor.

The primary advantage of this procedure is that the anterior flap raised from the thigh can be used to reconstruct an enormous posterior defect with little risk of flap necrosis. Patients who are expected to require radiation postoperatively should be considered for this procedure whenever possible, since the well-vascularized myocutaneous flap tolerates radiation well. Because of the vascular nature of this flap, the surgical wound heals rapidly in the vast majority of patients.

Accordingly, the 10–30% risk of ischemic necrosis associated with posterior flap hemipelvectomy is not seen with an anterior flap

procedure. Likewise, the risk of subsequent infection in the postoperative period is markedly reduced. Great care must be taken not to dissect or shear the subcutaneous tissue and skin overlying the quadriceps during the creation of the flap, because this will compromise the cutaneous circulation.

Rehabilitative considerations and the risk of phantom pain are similar to those associated with other types of hemipelvectomies. Because of the rapid healing seen with this type of flap, prosthetic fitting may be performed earlier. The large mass of quadriceps muscle provides a cushion of viable tissue on the sacrum on which prosthesis may comfortably rest without traumatizing the overlying skin.

PELVIC RESECTIONS:

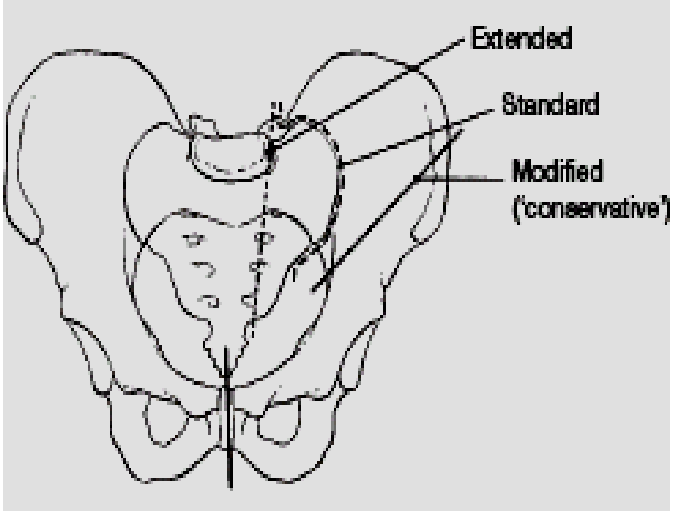
The pelvic girdle is a common location for primary bone sarcomas and metastatic lesions with the periacetabular region being the most common location, followed by the ilium and the pubis. Hemipelvectomy, the classic treatment for these lesions, has

been associated with dismal functional and psychological outcomes.

Improved survival of patients with musculoskeletal malignancies, and refinements in surgical technique, has allowed the execution of limb-sparing procedures in these situations. Local tumor control is good, as is the probability of a functional extremity. Internal hemipelvectomies, which involve resection of part or all of the innominate bone with preservation of the extremity, are now a reliable surgical option in the treatment of primary bone sarcomas, benign-aggressive lesions, and metastatic tumors of the pelvic girdle.

Classification of Pelvic Resections

Hindquarter amputation (hemipelvectomy, classical hemipelvectomy), using a posterior subcutaneous flap, was for a few decades the standard of treatment for large bone or soft-tissue tumors involving the proximal thigh, groin, or the periacetabular region. *Extended hemipelvectomy* includes sacral transection through the neural foramina. If a part of the iliac crest is spared, the procedure is referred to as *modified hemipelvectomy.*

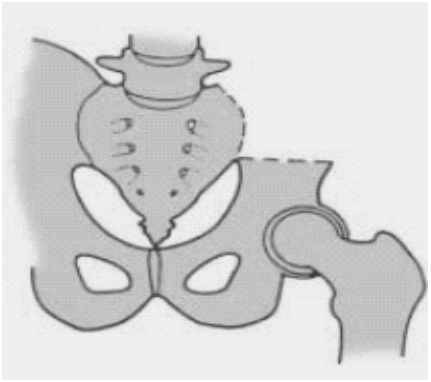


Hemipelvectomy can be performed using either the standard ***posterior or anterior myocutaneous flaps***. If the tumor mass is located in the buttock or high in the posterior thigh, and does not involve the femoral vessels, an anterior flap hemipelvectomy should be performed. In this procedure the surgical defect created by resection of the hemipelvis is covered by a rectus femoris myocutaneous flap.

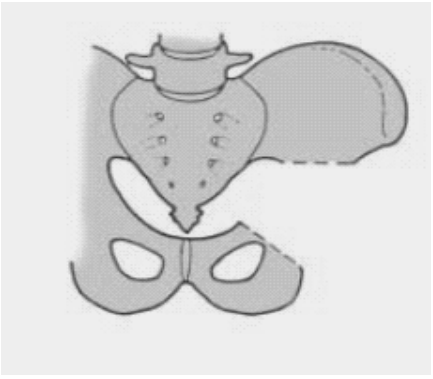
Internal hemipelvectomy (Pelvic resection) involves resection of part or all of the innominate bone with preservation of the extremity. The classification of these resections is attributed to ***Enneking*** and is based on the resected region of the innominate bone, from posterior to anterior:

- *Type I* – ilium

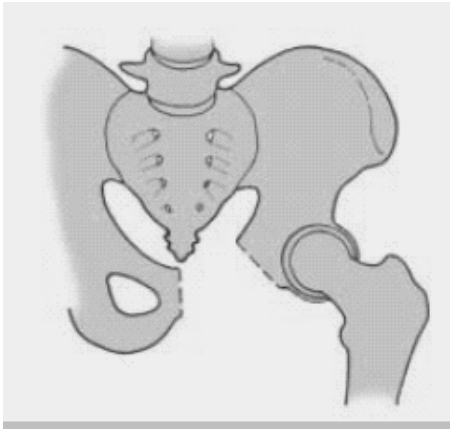
- *Type II* - periacetabular region
- *Type III* – pubis
- Extended *Type I* or *Type IV* resection - En-bloc resection of the ilium & sacral ala
- Type I pelvic (ilium) resection can be either (**A**) partial, in which only part of the ilium is transected, or (**B**) complete.



A: TYPE I PELVIC RESECTION



B: TYPE II PELVIC RESECTION



C: TYPE III PELVIC RESECTION

The Utilitarian Pelvic Incision:

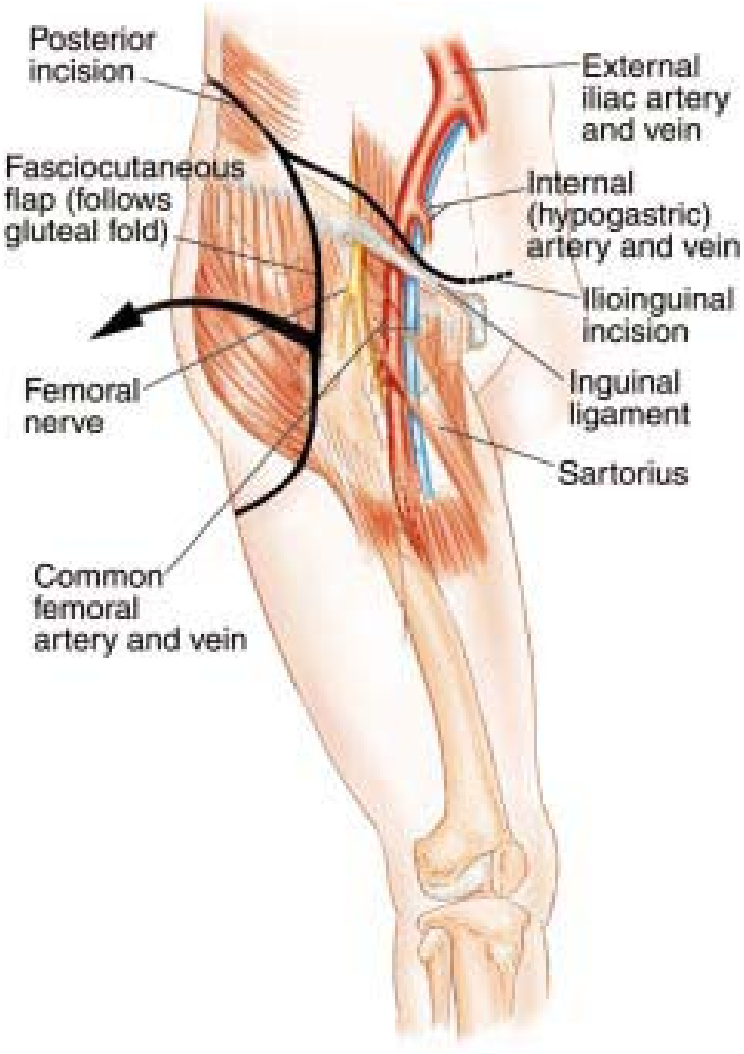
The most useful approach to pelvic biopsy or resection is the utilitarian pelvic incision. All or part of the incision can be used for adequate exploration and resection of the majority of pelvic girdle tumors.

The incision begins at the posterior inferior iliac spine and extends along the iliac crest to the anterior superior iliac spine. It is separated into two arms: one is carried along the inguinal ligament up to the symphysis pubis, and the other turns distally over the anterior thigh for one-third the length of the thigh and then curves laterally just posterior to the shaft of the femur below the greater trochanter and follows the insertion of the gluteus maximus muscle. Reflection of the posterior gluteus maximus flap exposes the proximal third of the femur, the sciatic notch, the sacrotuberous and

sacrospinous ligaments, the origin of the hamstrings from the ischium, the lateral margin of the sacrum, and the entire buttock.

A significant concern exists regarding the possible extracompartmental implantation of tumor cells following biopsy or resection of a pelvic tumor, procedures that are difficult to perform under optimal hemostatic conditions. Unnecessary biopsies must therefore be avoided. If biopsy is indicated, the proper technique and a suitable approach must be chosen. The biopsy tract has to be positioned along the line of the future utilitarian incision, remote from the major neurovascular bundle and the abductors.

CT-guided core needle biopsy is considered to be an accurate and safe diagnostic tool in the diagnosis of musculoskeletal tumors and is the preferred modality used by the authors.



Picture Showing the Utilitarian Pelvic Incision

The utilitarian incision may be used for hemipelvectomy by continuing the distal portion of the primary incision posteriorly around and behind the thigh and bringing it anteriorly along the inferior pubic ramus to the symphysis, thus encircling the thigh but still

allowing the large posterior flap to be used for primary wound closure.

Tumor evaluation

The presence of a palpable mass and its location, size, increase in local warmth, pulsatile nature, and degree of tenderness should be assessed by physical examination and the information recorded. Routine roentgeno-grams are sometimes helpful, but CT and especially MRI are essential.

Vascular studies of the lower extremity are sometimes useful in assessing the degree of partial occlusion, venous obstruction, or simply the proximity of the tumor to the vessels. An electromyography is sometimes useful in assessing the degree of damage to the nervous system; a CT of the chest and abdomen, a bone scan, and a positron emission tomographic scan frequently are helpful in determining the presence and extent of metastases.

A biopsy is an essential part of the tumor evaluation and can be obtained with greater accuracy by CT-guided core needle biopsy. An open biopsy may be necessary, but it should be through

the smallest possible incision, designed to be readily resectable at the time of definitive surgery.

Biopsy Technique:

General guidelines regarding positioning of the biopsy tract are applicable to biopsies of bone and soft tissue lesion and are independent of the technique

(Open versus needle biopsy) and anatomic location.

These guidelines can be summarized as follows:

- Most representative part of the lesion should be selected.
- As a rule the extraosseous component of a malignant bone tumor is as representative of the tumor as is the bony component, and should have biopsy, if present.
- Violating the cortex of a bone that harbors a malignant tumor, predisposes the patient to a pathologic fracture, and is recommended only if there is no extraosseous extension of the tumor.
- Position the point of entry along the planned incision of the definitive surgery

- The biopsy tract must be the shortest way to the lesion; however, it must not violate more than one compartment and must be as remote as possible from the main neurovascular bundle of the extremity.

The biopsy technique and placement is of paramount importance in periacetabular tumors as the risk of peritoneal and pelvic contamination is considerable and local control is a greater challenge. A misplaced or poorly performed biopsy can lead to extensive soft-tissue contamination and render resection difficult or not feasible. A poorly performed biopsy may be the primary reason a patient has a hemipelvectomy, and it may even interfere with soft tissue flaps necessary for wound coverage.

Most patients with periacetabular tumors are best served with a needle biopsy placed in the incision line of the planned future resection. CT guidance should be used unless there is a large extraosseous component that is easily accessible and away from critical neurovascular structures. The needle biopsy is performed anteriorly. The posterior approach should be avoided so as not to

contaminate the gluteus maximus, hip joint, femoral vessels, and femoral nerve.

For biopsy of the sacral tumors, the following guidelines are recommended (apart from the general guidelines):

- The biopsy site should be placed in the midline posteriorly, along the line of incision
- It should be placed in such a way that it should facilitate a contiguous en-bloc resection of the needle tract and tumor at the time of definitive surgery.
- should not contaminate the gluteal muscles
- should not be done transrectally or transperitoneally

Treatment planning

To provide the best possible treatment, the information obtained from the studies described previously must be reviewed carefully by a team that consists of the surgical oncologist, a medical oncologist, a radiation oncologist, a pathologist, and a radiologist, all of whom have experience and knowledge regarding bone and soft-tissue tumors. Based on the size, location, and nature of the tumor, the presence or absence of metastases, and the

patient's age and health status, a protocol must be established that could consist of one of the following:

- Wide or marginal surgical resection
- Surgical resection followed by radiation or chemotherapy or both
- Neoadjuvant chemotherapy or radiation therapy followed by surgery and, if necessary, additional adjuvant therapy
- Palliative radiation or surgery as necessary to address metastatic spread and local tumor by appropriate measures

Surgical techniques

Surgical approaches and techniques vary depending on the location of the tumor and the planned resection.

- For tumors of the iliac wing, the best approach is frequently along the iliac crest, which allows access to the anterior and posterior aspects of the tumor but may —if the tumor is large enough—causes some degree of skin vascular impairment.

- For tumors of the pubic rami, the longitudinal incision that runs along the pubis and extends to the ilium laterally and across the symphysis medially is often the simplest.
- For tumors of the ischium, an incision along the ischiopubic region that extends down the medial thigh and, if necessary, across the symphysis and into the region of the hip joint seems best.
- For tumors of the acetabular region, an anterior or lateral approach that extends into the thigh to add a hip replacement system is logical and relatively straightforward.
- For a total pelvic resection, either an extensive anterior approach (Smith-Petersen approach) or a long lateral incision starting at the crest and extending into the thigh is usually necessary.

Reconstruction

Techniques of surgical reconstruction include: ischiofemoral arthrodesis, iliofemoral arthrodesis, pelvic allograft, custom prosthesis, flail extremity, and, more recently, custom saddle prosthesis.

- Resection of the pubis often can be treated without any type of replacement or with an auto- or allograft insertion.
- Resection of the ischium usually requires no replacement system.
- Resection of a portion of the ilium need not be replaced unless the lesion area lies in juxtaposition to the sacrum, in which case an auto- or allograft can be implanted to maintain structure and function.
- Resection of the entire ilium and acetabulum can be treated by either resection and arthrodesis of the femoral head or trochanteric region to the sacrum or an allograft replacement without metallic femoral prosthesis or with a proximal femoral total joint

Reasons for poorer results in the management of pelvic tumors:

Although some authors have described reasonably good results for the treatment of some pelvic lesions, based on literature surveys there is little doubt that the treatment of patients with high-

grade sarcoma and metastatic carcinoma of the pelvis is considerably more difficult than for other sites.

The failure rate is higher, the disability levels are greater, and, as noted in this effort and in many others, the survival rate is considerably poorer. The question is not that it is so; all data support that. The two additional questions are why it is so and what can be done to make it better.

In terms of the causes for a poorer survival rate, there are several possible explanations.

1. The vascularity of pelvic tumors is significantly greater than in other more distal sites. Not only does this make the surgery more difficult in terms of blood loss but also it almost surely increases the likelihood of discharge of malignant tumor cells into the venous system at the time of surgery, which leads to an increased risk of metastasis. Another feature of the vascular issue is the internal body temperature at the site of the tumor, which is considerably higher than that for tumors in more distal sites. This may play a role in increasing the release of cytokines, such as the prostaglandins and

others, which may increase the malignancy of the tumor and the risk of metastasis.

2. The size of the tumors is often much greater in the pelvis than in other sites. Although the pelvis has a collection of nerves passing through it, it is still possible for tumors at this site to grow much larger with less recognition by the patient or the examining physician as compared with other more distal sites or in the upper extremities. A lesion 10 cm in longest diameter in the calf or thigh—or especially in the foot or hand—is hard to ignore, but a similarly sized lesion in the pelvis can exist without patient awareness as long as fracture or neural or vascular compression does not occur.

3. Surgical resection is often much more complex for pelvic tumors based on the proximity of blood vessels and nerves. Avoiding viscera and trying to save the femoral, sciatic, or obturator nerves or the internal iliac and femoral vessels and even some of the smaller arteries and veins can lead to not only a marginal resection but also an intralesional resection. As noted in the previous data, intralesional

surgical resection has a high mortality for pelvic lesions compared with marginal or wide resections.

4. Reconstructive surgery about the pelvis is complex and sometimes difficult. Restoring anatomy for the hip, maintaining the length of the limb, and retaining the function for the muscles are hardly simple tasks and sometimes require far more time and ingenuity than procedures in other anatomic sites. The duration of surgery increases the likelihood of infection and anesthetic complications. Most patients who receive pelvic surgery for high-grade tumors spend several days in a special care unit at our institution and frequently remain intubated and on intravenous fluids for a much longer period of time than patients who are treated for lesions in other anatomic sites.

Allograft Reconstruction

The biological principle behind allograft reconstruction is that they provide a bony lattice around which host bone elements from the periosteum creep and fill the graft. There is a host graft interaction by which the graft gets fused with the host bone like

fracture healing. This process is not usually complete in massive grafts where the host bone fills the peripheries only. But this process may take more time than normal fracture healing.

The major advantages of allograft over endoprosthesis are immediate availability of large grafts; the grafts can be trimmed to suit the donor defect and suturing of the soft tissues to the graft. There are two types of allograft reconstruction osteoarticular and intercalary. Intercalary grafts have superior results than osteoarticular.

The major disadvantages are increased wound related complications, 15 to 20% in most series. They require prolonged immobilization for the union to occur. There may be non union or fracture. They elicit an immune reaction which may lead to resorption of the graft as it happened in our case. The incidence of immune reaction is vastly reduced after freeze drying the graft. There is also a potential to transmit viral disease like HIV and Hepatitis though it is reduced by freeze drying or gamma sterilization.

In spite of these limitations, allograft reconstruction is an attractive option, because of the low cost involved and the

potential to acquire large number of grafts easily through development of bone banks.

REHABILITATION AFTER TOTAL SACRECTOMY

Physical and occupational therapists play an important role in improving function and increasing patients' independence with activities of daily living. Goal of rehabilitation is restorative with an emphasis on increasing functional independence while maintaining structural integrity of the surgical site.

Urinary retention and rectal insensitivity requires the need for self catheterization and a strict bowel regimen. If only the L5 nerve is preserved, patients may require a brace for ambulation. They may have difficulty going up and down stairs secondary to partial loss of gluteus maximus function and decreased hip extension. Although in most patients hypertrophy of the hamstrings and adductor muscles may compensate for this loss allowing for a close to normal gait pattern.

In order to avoid shearing forces at the site of the flap posteriorly, sitting is contraindicated for 10 to 14 days after surgery. This restriction may be extended in patients who require wound irrigation and drainage after surgery. Therefore functional tasks and activities of daily living are performed in supine, sidelying, or standing positions. Immediately after surgery, patients are often placed on bed rest on a Clinitron Rite Hite Air Fluidized Therapy Bed for 1 to 3 days. Clinitron beds are designed to promote wound healing and prevent skin break down. To help patients with mobility on the Clinitron bed a trapeze is placed above the bed to assist with bed mobility and transfers out of the bed.

Physical therapy is usually initiated postoperative day 3. Physical therapy evaluation must include a thorough motor and sensory evaluation of the lower extremity, trunk, and upper extremity. Bed mobility, transfer training, and patient and family education are 3 important general short-term restorative goals. Progress with short-term goals and treatment intensity depends on patient's general

physical and medical condition after surgery and the presence or absence of postsurgical complications.

As indicated sitting is almost always contraindicated for 10 to 14 days after a total sacrectomy to protect the incision site and allow time for healing. Therefore education and independence with safe out of bed transfer is the primary focus of physical therapy intervention during the first postoperative week. To ensure patient independence and safety with the supine to stand transfer, patients are instructed in log rolling, using their upper extremities to flex the trunk and assisted in lower extremity transfer out of bed. This transfer is often done with maximum assistance of 2 therapists during the first 1 to 3 days after the initial evaluation. The level of assistance is gradually decreased based on patients' progress with the technique. A realistic short-term goal (3 days after initial evaluation) would be a transfer out of bed that requires minimum to moderate assistance of one person.

Patient, family, and the nursing staff are educated on transfer training as well as proper positioning in bed with periodic sidelying to

prevent skin breakdown. In addition to the training provided by physical therapists, patients work with occupational therapists to gain independence in self care activities.

Occupational therapy is often initiated at the same time as physical therapy. Prior to discharge from the hospital the nursing staff educates patients on self catheterization and bowel regimen; however, patients often times need home care services to help them with this postoperative complication.

Most patients are discharged home with an ability to transfer out of bed independently and ambulate 250 to 500 feet with a rolling walker. Rehabilitation following total sacrectomy is challenging and rewarding at the same time. Increasing patient independence and safety with transfers while maintaining sitting restriction is one of the hardest goals to achieve during therapy. The intensity and progression of therapy is often limited due to the long surgical procedure, extensive blood loss, and possible complications following surgery.

MATERIALS AND METHODS

The patients who were diagnosed to have musculoskeletal tumors of pelvis and operated (either Sacrectomy/ Hemipelvectomy or Pelvic resection) in the Department of Surgical oncology, Government Royapettah Hospital, (Kilpauk Medical College) Chennai, Tamil Nadu were included in the study. The study period is from February 1997 to May 2009.

Pre operative work up included chest X-ray, CT scan and/ or MRI of pelvis, CT scan chest, Biopsy either in the form of core needle biopsy, CT guided Biopsy or Open biopsy(when the previous methods fail) assessment of cardiopulmonary status and routine blood investigations.

Each patient is discussed in the panel headed by the surgical oncologist, a medical oncologist, radiation oncologist, oncopathologist, radiologist, physiotherapist, rehabilitation personnel & stoma therapist. Surgery done may be in the form of either:

- Sacrectomy → partial/ subtotal/ total/ Hemisacrectomy/ partial sacrectomy with curettage.

or

- External Hemipelvectomy

or

- Pelvic resection (Type I/II/II/IV)

Sacrectomy is done with either one of the following approaches:

- Posterior approach
- Sequential abdominosacral approach
- Staged abdominosacral approach

Pelvic resection is done with utilitarian pelvic incision approach

Duration of surgery, blood loss, length of hospital stay, post operative complications, local recurrence, distant metastasis, survival rate, use of adjuvant therapy, functional outcome measures including ambulatory ability and bowel & bladder control were analyzed.

Patients were followed up monthly for the 1st year, once in 2 months for the 2nd year, 3 monthly thereafter. Clinical examination, imaging with CT scan was done during follow up.

Survival analysis done with Kaplan meier method (with spss). Functional & Oncological outcome was analyzed and the results were compared with that in the literature.

Functional outcome in our series is measured by a self designed Royapettah scoring scale for assessing the functional outcome of musculoskeletal tumors of pelvis treated with sacrectomy/hemipelvectomy (given in the proforma).

ANALYSIS AND RESULTS

In this series of 26 patients with musculoskeletal tumors of pelvis, 17 patients underwent Sacrectomy, 8 patients underwent Pelvic resection and 1 patient underwent External Hemipelvectomy (Chart No 1).

The common diagnosis in our series is listed in the Table No 1 & 2.In our series, Giant cell tumor (n=7) is the most common sacral tumor, followed by Chordoma (n=6). Chondrosarcoma is the most common pelvic tumor treated with pelvic resection.

The average age at diagnosis was 33 years (range 15-65 years). There were 16 males and 10 females. 2 patients were given

neoadjuvant chemotherapy and taken for surgery (PNET Pelvis, Ewing's sarcoma Pelvis).

Partial Sacrectomy was done in 6 patients, Partial Sacrectomy with Curettage in 2, Total Sacrectomy in 4, Subtotal Sacrectomy in 3, Subtotal Sacrectomy with Type I Pelvic Resection in 1 and Hemisacrectomy in 1 patient.

Type IV Pelvic Resection in 4, Type I/II/III Pelvic Resection (or combined) in 4 and External Hemipelvectomy (Anterior Flap Hemipelvectomy) in 1 patient. (Table No 3).

Table No 1

SACRAL TUMORS	**n**
Giant cell tumor	7
Chordoma	6
Myxopapillary Ependymoma	1
Chondroblastoma	1
Primitive Neuroectodermal tumor	1
Chondrosarcoma	1

Table No 2

PELVIS TUMORS (excluding sacral tumors)	**n**
Chondrosarcoma	4
Hemangioendothelioma	1
Aneurysmal Bone Cyst	1
Primitive Neuroectodermal tumor	1
Ewing's sarcoma	1
Malignant peripheral Nerve sheath tumor	1

Table No 3

SURGERY	**SURGERY**	**n**
SACRECTOMY	Total Sacrectomy	4
	Subtotal Sacrectomy	3
	Subtotal Sacrectomy + Type I Pelvic Resection	1
	Partial Sacrectomy	6
	Partial Sacrectomy with Curettage	2

	Hemisacrectomy	1
PELVIC RESECTION	Type IV Pelvic Resection	4
	Type I+II Pelvic Resection	1
	Type II+III Pelvic Resection	3
External Hemipelvectomy	Anterior Flap Hemipelvectomy	1

Anterior Flap Hemipelvectomy was done in a 16 year old boy with MPNST Right gluteal region (case No 25), since limb salvage and posterior flap hemipelvectomy was not possible for him as the gluteal region was contaminated by inappropriate placed incision biopsy done elsewhere (Figure No 1a -1h). There was no post operative complication or flap necrosis and the patient was made ambulant.

Composite pelvic exenteration (total sacrectomy) + end Colostomy was done in a 29 year old male, (case No12) with Giant cell tumor sacrum infiltrating the rectum. Post operatively the patient developed complete wound dehiscence, necrosis & Vesicocutaneous fistula. He died on the 60th post operative day because of pulmonary thromboembolism.

Sacrectomy was performed by either one of the following approaches: posterior approach (2 patients), Sequential abdomino-sacral approach (8 patients), and staged abdomino-sacral approach (7 patients).

In the ***Staged abdomino-sacral approach***, on the day one of operation, with the patient in supine position, midline laparotomy was done, and the iliac vessels, rectum, anterior aspect of sacrum & tumor was defined. Vascular control of iliac vessels obtained (Fig No 2a). Level of amputation planned and anterior osteotomy done. For adequate hemostasis, the pelvic cavity is packed with Gel foam & Roller Gauze pack (Fig No. 2b) (which is removed on the next day during the posterior approach). Abdomen is closed with pelvic drain.

On the day two of operation, with the patient in prone position, posterior approach done – lumbosacral laminectomy done, dura identified & ligated, tumor delineated, uninvolved sacral nerve roots preserved, sacral amputation completed & specimen and the pack removed (Fig No.2c-e). The dura is ligated doubly with 2-0 silk. And gel foam is kept over it or muscle cover is done with paraspinal muscles.

In our series, this method of performing the operation on two subsequent days has markedly reduced the patient morbidity in terms of blood loss, reduction of operating time, anesthetic complications, wound healing thereby patient's functional outcome and post operative hospital stay.

In our series, we define the operation (Fig No.3) as

- Total sacrectomy: when the level of amputation is at L5S1 disc with complete removal of sacrum. Even if, only the ala on one side of S1 vertebra is retained and rest of the sacrum is removed, we consider the operation as Total Sacrectomy.
- Subtotal sacrectomy: when the level of amputation is at the body of S1 vertebra, through the level of S1 foramina, preserving the S1 nerve root and both the ala of S1 vertebra are preserved, we consider the operation as subtotal sacrectomy (spinopelvic continuity is maintained)
- Partial sacrectomy: when the level of amputation is at or below the body of S2 vertebra, through the level of S2 sacral foramina, preserving the S2 nerve root, we consider the operation as partial sacrectomy.

Whenever feasible, we try to preserve the uninvolved nerve roots irrespective of the bone cut made.

Soft tissue reconstruction was done with Bilateral Gluteal advancement flap in 6 patients (table No 4). Omental flap has also been used to isolate the peritoneal cavity from the pelvic cavity.

Table No 4

Soft Tissue Reconstruction	Total	n=6
Gluteal advancement flap	Sacrectomy	n=4
	Pelvic resection	n=2

Although Spinopelvic reconstruction was not done in any of the patients in the Sacrectomy group, none of our patients developed major spinal instability since the transverse process of L5 vertebra & the iliolumbar ligaments were left undisturbed even in total sacrectomy.

Pelvic resection was done by utilitarian pelvic incision approach. 5 patients in hemipelvectomy group underwent bony reconstruction (Table No 5).

Table No 5

BONY RECONSTRUCTION	**n**	**Diagnosis**	**Procedure done**
Fibular strut graft	1	Aneurysmal Bone Cyst Right Ilium	Type IV Pelvic Resection Right + Fibular strut graft
DCP plate & screw fixation	1	PNET Pelvis	Type II + III Pelvic Resection Lt + DCP plate & screw fixation
Cadaveric allograft bone transplantation	1	Chondrosarcoma pelvis	Type II Pelvic Resection Rt + Cadaveric allograft bone transplantation
Extra Corporeal Pelvic Bone Irradiation & →reimplantation	1	Ilium tumor-Hemangioendothelioma	Type IV Pelvic Resection Rt → Extra Corporeal Pelvic Bone Irradiation & →reimplantation
Iliofemoral arthrodesis	1	Ewing's sarcoma pelvis	Type II + III Pelvic Resection Lt + Iliofemoral

			arthrodesis

Type IV pelvic resection & reimplantation of the Extra Corporeally irradiated Pelvic Bone was done for a 13 year old boy with right ilium tumor (Hemangioendothelioma) [Figure No 4 a-e]. Extracorporeal irradiation of the specimen was done by Cobalt Teletherapy with AP & PA portals to a total dose of 50Gy. Irradiated pelvic bone reimplanted into its position & fixed with plate & screws.

But after 2 months, the patient developed osteomyelitis and autograft rejection and so the autograft was removed.

There are very few reports of Intra-operative extracorporeal irradiation and re-implantation of the bone segment. Extracorporeal irradiation is ideally done with Linear Accelerator.

Advantages being: large doses of RT can be delivered to the tumor while avoiding the dose delivered to other tissues, the autograft fits aptly in its native anatomical position, easy availability, good adaptation of size & shape, no risk of disease transmission, preservation of bone stock and ligamentous tissue, and no

immunologic reaction. There is no evidence of increased rate of recurrence with extracorporeal irradiation & furthermore, no local recurrence been reported after extracorporeal irradiation.

Complications include avascular necrosis & resorption of the graft fracture & non union. Another disadvantage is the lack of material for histopathological analysis of the resection margins.

Type II + III Pelvic resection & Cadaveric allograft bone transplantation was done for a 28 year old male with recurrent chondrosarcoma of the periacetabular region. Reconstruction was done with freeze dried cadaveric pelvic bone. Allograft pelvic bone was tailored to suit the defect and fixed to the patient's pelvic bone with plates and screws at pubis and ilium (Figure 5 a -f). Femoral head was made to articulate with the graft's acetabulum and fixed with screws. Soft tissue reconstruction was done.

After 4 years, the allograft has completely resorbed and is replaced by fibrosis. The stability of the pelvis is good. Patient is ambulant independently without any assisting devices and is able to carry out his routine activities with an excellent functional outcome.

Although the graft has completely resorbed, it has provided a lattice for fibrosis to occur. In spite of its limitations, allograft is an attractive option because of the low cost involved and the potential to acquire large number of grafts easily.

The mean blood transfused in the whole series is 6 units; 8 units in the Sacrectomy group & 3 units in the Hemipelvectomy group. The average duration of surgery is listed in the Table No 6.

Table No 6

AVERAGE DURATION OF SURGERY	Total	7 hours
	Sacrectomy	7 hours
	Hemipelvectomy	6 hours

The post operative complications were enumerated in the table No 7 & Chart No 2. Overall 15 patients (57.7%) developed post operative complications which is comparable to that in literature of 50-70%.

Most patients developed wound problems like wound dehiscence and necrosis. Wound complications were managed

either with debridement, SSG, secondary suturing, gluteal advancement flap or healing by secondary intention.

Majority of the wound dehiscence in our series was observed to be due to extensive soft tissue resection, prolonged duration of surgery, primary closure of the wound without Gluteal advancement flap, necessity to ligate Superior Gluteal vessels, associated co morbid conditions of the patient and prior Radiation.

Table No 7

POST OPERATIVE COMPLICATIONS	TOTAL	SACRECTOMY	HEMIPELVECTOMY
Wound Dehiscence/ Necrosis	n=15	n=10	n=5
Bladder/ Bowel Incontinence	n=9	n=9	n=0
Meningitis	n=1	n=1	n=0
Posterior Defect Rectal Hernia	n=1	n=1	n=0

DVT	n=1	n=0	n=1
Vesicocutaneous Fistula	n=1	n=1	n=0
Pulmonary Thromboembolism	n=1	n=1	n=0

Bilateral gluteal advancement flap was performed in 7 cases, 6 at the same stage and one for the management of rectal herniation through the sacral defect.

9 patients (34.6%) developed bladder & bowel disturbances. Bladder incontinence was managed either with intermittent self catheterization or with Diapers. Bowel problems were managed with regular enemas.

Perioperative mortality in our series is 7.69% (n=2) which is in the range with that of literature of 5 – 10%. One patient (case No 17) in the sacrectomy group died on the 60th post operative day due to meningitis & septicemia.

The other one, as already mentioned above, was a 29 year old male with Giant cell tumor of sacrum (case No 12) who underwent

composite pelvic exenteration + Total sacrectomy + end colostomy died on the 60th post operative day due to pulmonary thromboembolism.

Posterior Defect Rectal Hernia in the case No 5 was managed with hernia repair & Bilateral Gluteal advancement flap.

The average post operative hospital stay was 42 days in the whole group, 47 days in the Sacrectomy group & 32 days in the Hemipelvectomy group.

The post operative morbidity in sacrectomy is significantly less in the staged abdomino-sacral approach when compared to the Sequential abdomino-sacral approach. (Table No 8)

Table No.8 Comparison between the sequential & staged abdomino sacral approaches

SACRECTOMY APPROACH	n	Mean operating time (Hours)	Mean Blood transfused (in units)	Wound complication rate	Anesthetic recovery	Average post op stay(in days)

Sequential abdomino-sacral	8	8	11	6 cases-75%	Delayed	53
Staged abdomino-sacral approach	7	6	3.7	4 cases – 57 %	Not affected	42

From the table No 8, it is obvious that with the staged abdominosacral approach of sacrectomy, the mean operating time is 2 hours less, wound complications are ≈20% less, and the average length of hospital stay is 11 days less when compared to the Sequential abdomino-sacral approach.

Adjuvant Chemotherapy was given in 4 cases (PNET Pelvis, Ewing's sarcoma Pelvis, PNET Sacrum, Hemangioendothelioma ilium).

Adjuvant radiation was not given in any of the patients (excluding the case of extra corporeal pelvic bone irradiation).

With a median follow up of 19 months (range 2-147 months), the survival rates are as follows: (Table No 9; Graph No 1, 2 & 3).

- 5 year Overall survival
  - ✓ Sacrectomy group is 65%
  - ✓ Hemipelvectomy group is 76%.
- 5 year Disease free survival
  - ✓ Sacrectomy group is 68%
  - ✓ Hemipelvectomy group is 76%
- 5 year Overall survival
  - ✓ non recurrence group is 78%
  - ✓ recurrence group is 50%
- Although the p value (by log rank analysis) is not significant (p value - 0.4678), there is a substantial difference between the recurrence and non recurrence group.

Table No 9

SURVIVAL ANALYSIS	SACRECTOMY	HEMIPELVECTOMY	LITERATURE
5 year Overall	65%	76%	50-60%

survival			
5 year Disease free survival	68%	76%	50%

Local recurrence (n=5) rate was 19.32%. In two cases, the recurrence was resected and the patients are disease free on follow up.

- *The median duration for 1st recurrence was 12 months (range 3-17)*
- *4 patients developed distant metastasis*
    - pulmonary metastasis - 3 patients
    - Liver & vertebral metastasis - 1 patient

The current status of the patients is enumerated in the table No 10 & Chart No 3.

Table No 10

Current status	Total	Sacrectomy	Hemipelvectomy
Lost Follow Up	10	4	6
Local Recurrence	5	4 (2 operated & disease free now)	1
Distant Metastasis	4	2	2
Death	7	5 (including 2 perioperative mortality)	2

The functional outcome was assessed according the Royapettah scoring scale for musculoskeletal tumors of pelvis; (Chart No 4).

- ✓ good outcome - 12 patients (46%)
- ✓ fair outcome - 8 patients (31%)
- ✓ poor outcome - 6 patients (23%)

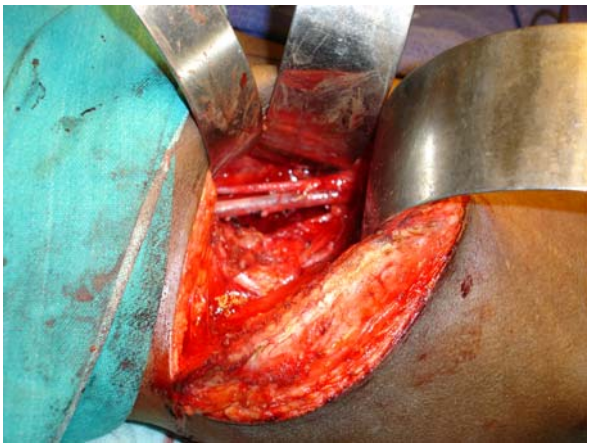
77% of our patients had an acceptable functional outcome (good or fair). And only 23% did not fare well after surgery. Overall

the results & outcome (oncological and functional) in our series is in par with that reported in the literature.

Figure 1:Photographs of case No 25 (MPNST right gluteal region) – Anterior Flap Hemipelvectomy was done

Figure 1a):Wrongly placed Biopsy incision contaminating the posterior flap

*Fig 1b):*External iliac vessles isolated



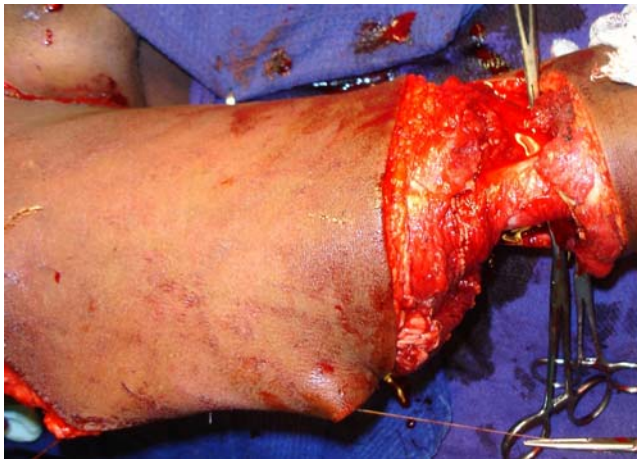


Fig 1c) Anterior thigh myocutaneous flap isolated

Fig 1d; Hemipelvectomy completed: defect showing the cut ends of sacrum posteriorly, cut end of pubis anteriorly, Bladder & Rectum inbetween: anterior thigh flap reflected above

Fig 1e) Defect closed with the anterior flap photograph

fig 1f) resected specimen

Fig 1 g& h) the wound healed well; patient is made to walk with crutches

Figure 2: photos of case 17 (chondrsarcoma of sacrum)–subtotal sacrectomy+Type I pelvic resection

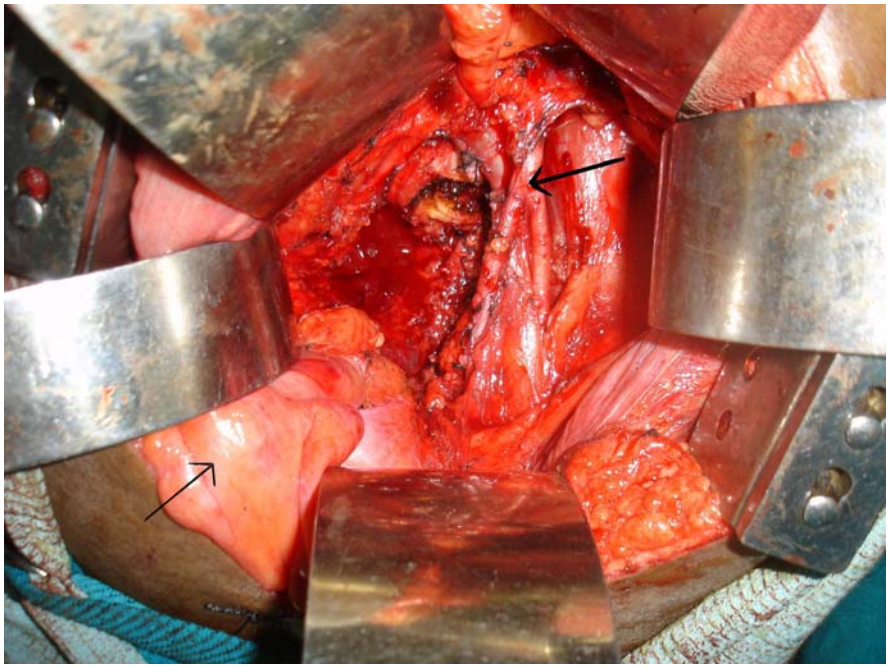


Figure 2a): Abdominal procedure of the 2 staged sacrectomy: anterior approach & vascular isolation of iliac vessels. [Rectum (lower arrow mark) mobilized aside: iliac vessels delineated (upper arrow mark)]

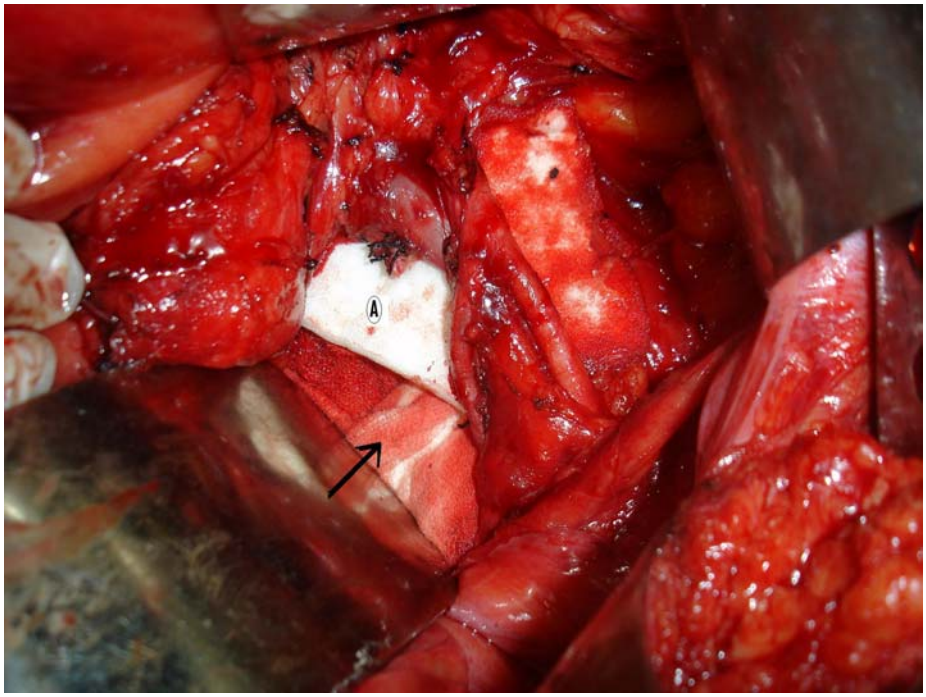


Figure 2b) anterior approach is completed & gelfoam (A) & roller gauze pack (arrow mark) packed into the cavity for hemostasis

Figure 2c) *2nd stage (sacral approach)* of the staged abdominosacral approach: sacrectomy is on the way; the arrow mark showing the dissected specimen

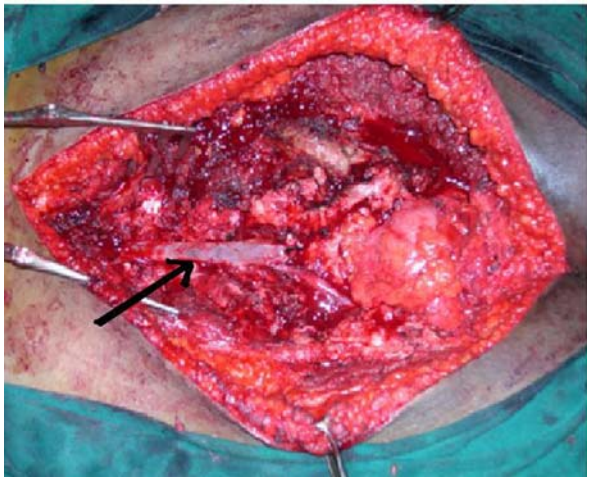


Figure 2d); posterior approach;
Lumbosacral
Laminectomy done and the dura exposed
(As shown by the black arrow mark)

Figure 2e) specimen photograph

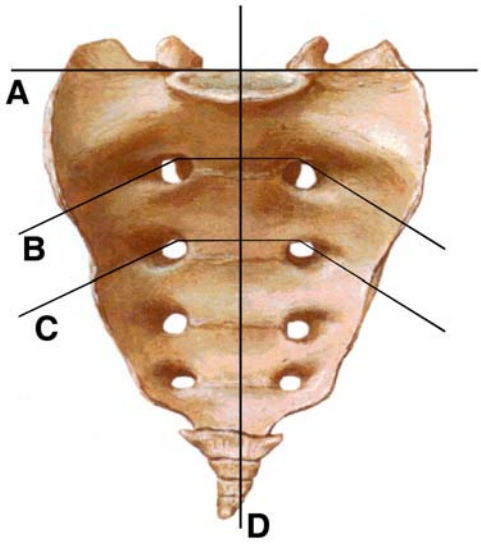


Fig 3- Picture representing the levels of amputation. A-Total sacrectomy; B-Subtotal sacrectomy; C-Partial sacrectomy; D-Hemisacrectomy

Figure4: case No 18: Hemangioendothelioma Right ilium; Pelvic resection & reimplantation of erxtracorporeally irradiated pelvic bone

Fig 4a) utilitarian pelvic incision including the biopsy scar

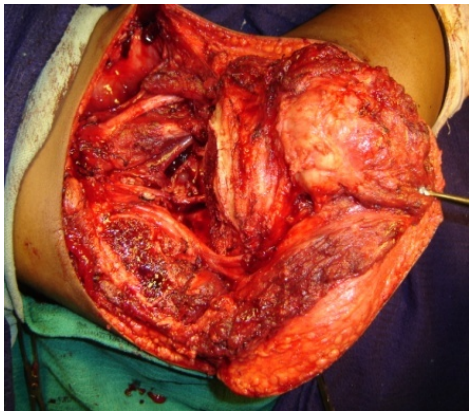


Fig 4b) after completion of resection

Fig 4c) After resection, soft tissues of the specimen removed

Fig 4d) autograft packed in a sterile container for extra corporeal irradiation

Fig 4e) Post operative X-ray showing the autograft in situ.

Figure 5: Photographs of case No 21 (Recurrent Chondrosarcoma of actebulum) – Type II + III pelvic resection followed by allograft reconstruction

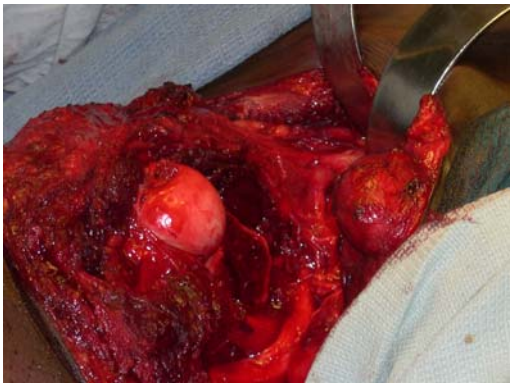


Fig 5a) Defect after resection Femoral head in disarticulated position.

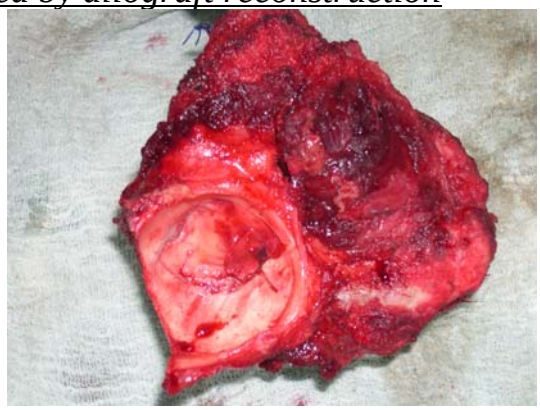


Fig 5b) Specimen photograph

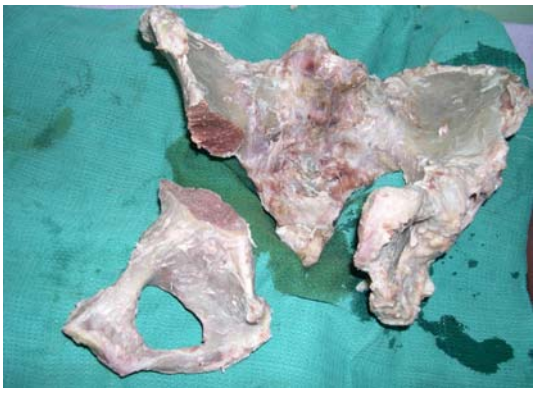


Fig 5c &d): Freeze dried Allograft which was osteotomized to suit the defect.

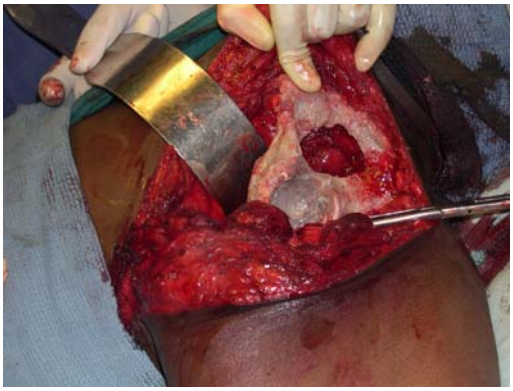


Fig 5e): Allograft is placed in defect, to be fixed with screws and plates

Fig 5f) Immediate post operative X ray showing allograft fixed with plates and screws

Chart No 1

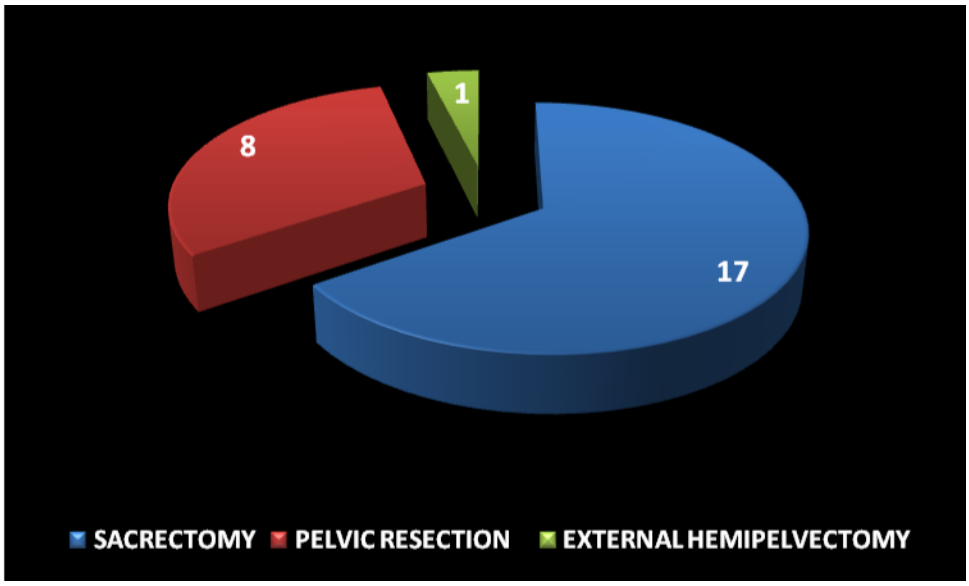


Chart No 2 – Post operative complications

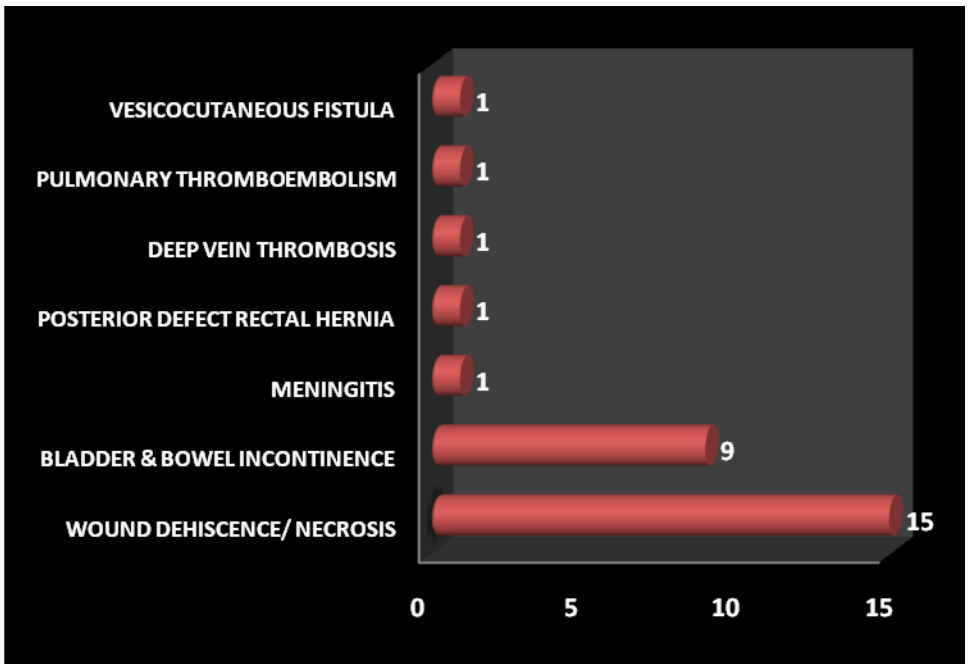


Chart No 3

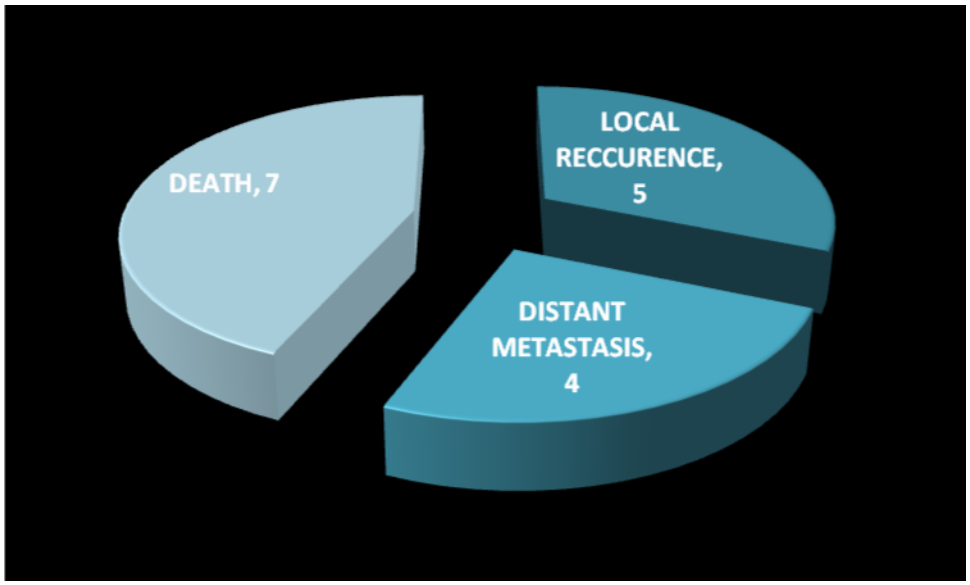
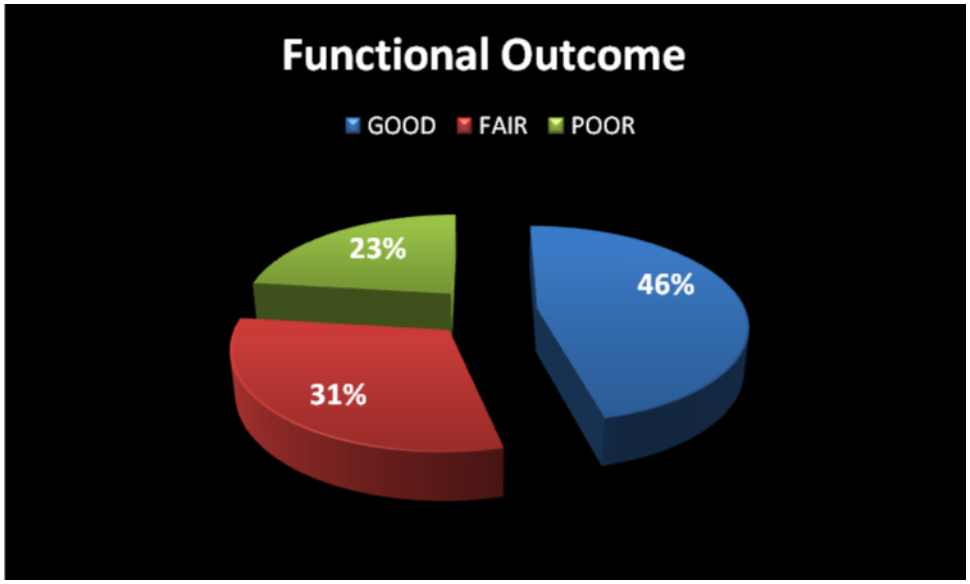
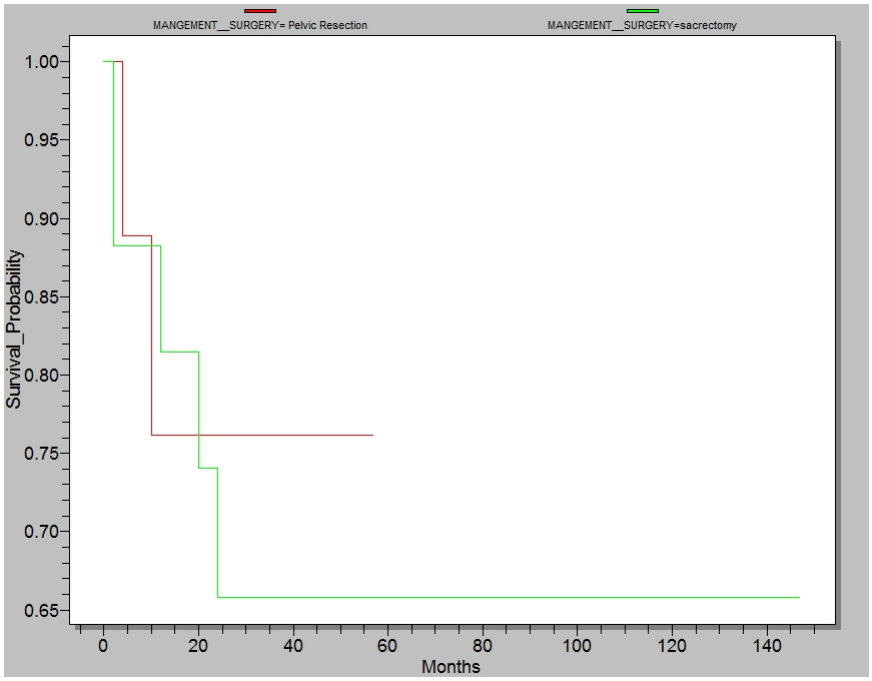


Chart No 4

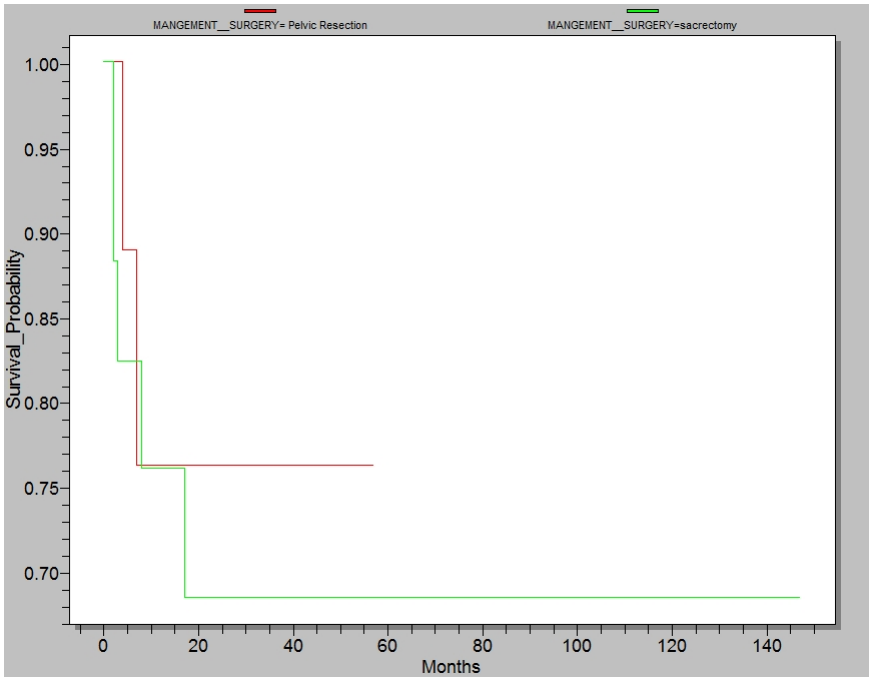


Graph No 1: 5 year Overall survival



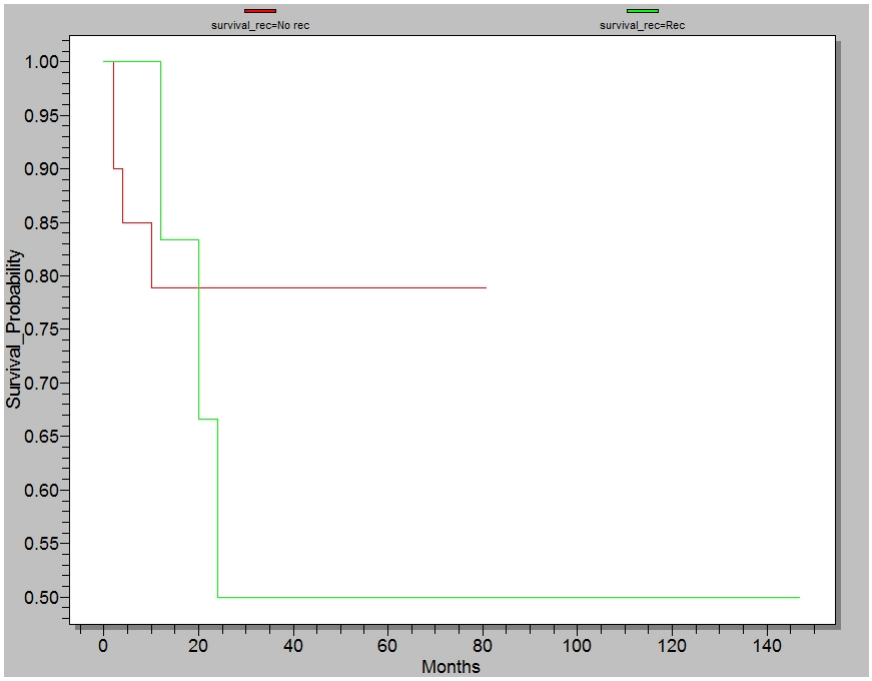
Sacrectomy – 5yr overall survival 65%; Hemipelvectomy – 5 yr overall survival – 76%

Graph No 2: 5 year Disease free survival



Sacrectomy –5 year DFS - 68%; Hemipelvectomy – 5 year DFS 76%

Graph No 3: 5 year Overall survival in recurrence and non recurrence group



No recurrence – overall survival -78%
Recurrent group – overall survival 50%

Test	Statistic	D.F.	P-Value
Log-Rank	0.5273	1	0.4678
Wilcoxon	0.0072	1	0.9326

CONCLUSION

Bone and soft-tissue sarcomas that arise in the pelvis are difficult to treat. Tumors can be large and destructive before discovery, and they often involve vessels and nerves. Achieving a wide or even a marginal surgical resection margin may be technically complex at times.

Historically, patients with pelvic tumors were treated with hemipelvectomies. These operations not only were fraught with complications but also in most cases represented physical, functional, and psychological problems for the patients.

Several studies have described the difficulties patients have with such a procedure, and there is little doubt that regardless of the problems associated with the internal hemipelvectomies and reconstructions, such procedures are preferred to total limb ablation.

Sacrectomy, one of the neglected & morbid operations, is feasible now with modified and improved surgical techniques. Although a morbid procedure, sacrectomy with improved surgical

techniques improves oncological outcome and patients' quality of life.

The staged abdomino – sacral approach significantly reduces the mean operating time, blood loss, wound complications and immediate post operative morbidity. Gluteal advancement flap reduces the incidence of wound dehiscence and necrosis. Sacrectomy is feasible with moderate surgical facilities and post operative care by the staged abdomino sacral approach.

It seems that the critical comment regarding all this is that almost no matter what the tumor is and how it is treated, 50% of the patients survive, particularly if the margins are marginal or wide and adjunctive treatment is administered. That level of success is not as good as we would like, but it is certainly a baseline start to see if some efforts will help improve the outcome.

Based on the data, the approaches must include improved surgical techniques, altered adjuvant therapy protocols, and better mechanical restoration systems. These are clearly the directions we must take if we are to improve the status and outlook for these patients.

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SURGICAL OUTCOME OF MUSCULOSKELETAL TUMORS OF PELVIS
PROFORMA

S.No

Name : C.D No

Age:
Sex:
Occupation:
D.O.A:
D.O.S :
D.O.D:

C.OP No
I.P. No
Address
(& Ph No)

DIAGNOSIS	
TNM STAGING	
STAGE GROUPING	

COMPLAINTS AND DURATION:

Swelling	Y/N
Pain	Y/N
Weakness of Limbs/Difficulty in walking	Y/N
Pain of Lower Limbs (radiating)	Y/N
Sensory Disturbance (Loss of Sensation/Altered Sensation)	Y/N
Swelling of Limbs/Foot	Y/N
Urinary Symptoms (Incontinence/Retention/Frequency/ Hematuria/Dysuria)	Y/N
Altered Bowel Habits (Incontinence/Constipation/ Diarrhoea/Bleeding PR)	Y/N
Loss of Appetite	Y/N
Loss of Weight	Y/N
Family H/o Malignancy	Y/N (1^{st} /2^{nd}/3^{rd} Degree Relative)
Previous H/o Malignancy	Y/N

H/O PREVIOUS TREATMENT

Surgery

Radiotherapy: Total Dose: No. of Fractions: Completed On
Chemotherapy:Drugs No.of Cycles

Previous Biopsy Y/N
Type (FNAC/Core Needle Biopsy/Incision Biopsy/Excision Biopsy)
Histology

Smoker/Alcoholic/Nonsmoker/Nonalcoholic: Married/Unmarried
Comorbid Illness DM/HTN/IHD/COPD/TB

CLINICAL EXAMINATION:

Performance Status (ECOG scale) 0 / I / II / III / IV
Previous Biopsy Scar Y/N
Site: Length:
Orientation of the scar with respect to future definitive surgical planning & incision

EXAMINATION OF SWELLING

Site & Size
Mobile/Fixed
Skin involvement Y/N
Bone involvement Y/N
Bone involved
Soft tissue involvement Y/N
Muscle involvement Y/N
Muscles involved
Vascular involvement Y/N
Vessel affected
Nerve involvement Y/N
Nerve affected
Lower limb edema Y/N
Unilateral/Bilateral
Pitting/Non pitting

ARTERIAL PULSE OF LOWER LIMB

ARTERIAL PULSE	RIGHT	LEFT
Femoral		
Popliteal		
Dorsalis pedis		
Posterior Tibial		

POWER OF LOWER LIMB

(MRC classification)

MOVEMENT	RIGHT	LEFT
HIP		
Flexion	**/ 5**	**/ 5**
Extension	**/ 5**	**/ 5**
Abduction	**/ 5**	**/ 5**
Adduction	**/ 5**	**/ 5**
External rotation	**/ 5**	**/ 5**
Internal rotation	**/ 5**	**/ 5**
KNEE		
Flexion	**/ 5**	**/ 5**
Extension	**/ 5**	**/ 5**
ANKLE		
Dorsiflexion	**/ 5**	**/ 5**
Plantar flexion	**/ 5**	**/ 5**
TOES		
Dorsiflexion	**/ 5**	**/ 5**
Plantar flexion	**/ 5**	**/ 5**

SENSATION Rt Lt
Anesthesia/Paraesthesia
Area affected
Dermatomes affected

DIGITAL RECTAL EXAMINATION
Mass felt Y/N: Anteriorly / Posteriorly / Rt Lateral / Lt lateral
Mucosa involved: Y/N: Sphincter tone

LYMPH NODES Y/N
Site

DISTANT METASTASIS Y/N
Site

INVESTIGATIONS
Hb% Blood sugar:
Blood urea: S.Creatinine: S.Alkaline Phosphatase

FNAC

BIOPSY: Core Needle Biopsy/ Incision Biopsy/ Excision Biopsy
Histology Grade Immunohistochemistry

CHEST X-RAY
Normal
Lung Metastasis: Single / multiple (2 / 3 / 4 / 5 / >5): Unilateral / Bilateral

LOCAL PART X-RAY
Site & Size of lesion
Type Osteolytic/Osteosclerotic/Mixed
Calcification Y/N
Margin well defined/ill defined
Cortical destruction Y/N
Pattern of destruction Geographical / permeasive/Moth eaten
Extraosseous extension Y/N
Periosteal elevation Y/N

CT SCAN LOCAL PART/ MRI SCAN
Site & Size
Infiltrating adjacent structures Y/N
Structure infiltrated
Extension into sciatic notch Y/N
Margin well defined/ill defined
Bone involved Y/N
Bone destruction Y/N
Muscles involved
Nerve displaced/involved/not involved
Nerve affected
Blood Vessel displaced/involved/not involved
Blood vessel affected
Calcification Y/N
Hemorrhage Y/N
Necrosis Y/N
Bladder involved Y/N
Rectum involved Y/N

BONE SCAN
CT SCAN CHEST
Normal
Lung Metastasis: Single / multiple (2 / 3 / 4 / 5 / >5): Unilateral / Bilateral

TREATMENT

NEOADJUVANT CHEMOTHERAPY Y/N

Drugs No. of cycles Response

SURGERY

SACRECTOMY *Total / Subtotal/ Partial/ Hemisacrectomy*

Approach
Level of resection
Nerve roots sacrificed
Nerve resected
Dura intact Y/N
CSF leak (intra operative) Y/N

HEMIPELVECTOMY (CLASSICAL)

Posterior Flap Hemipelvectomy/Anterior Flap Hemipelvectomy
Standard/ Extended/ Modified (Conservative)/ Compound
Adjacent organ removed ……..

PELVIC RESECTION *TYPE I/II/III/IV*

Vascular Resection
Vascular Reconstruction
Nerve resection
Reconstruction Y/N

Reconstruction with
saddle prosthesis
allograft
prosthesis replacement
iliofemoral arthrodesis
ischiofemoral arthrodesis

Colostomy Y/N
Ileostomy Y/N
Ileal conduit Y/N
Colonic conduit Y/N
Duration of Surgery
Blood Loss
Blood transfusion given

POST OPERATIVE COMPLICATION

Wound infection	Y/N
Wound dehiscence	Y/N
Flap necrosis	Y/N
Treated by	secondary suturing Wound debridement SSG Flap reconstruction Healing by secondary intention
Fistula	
Thromboembolic manifestation	Y/N
Colostomy/ Ileostomy complication	hernia/ stenosis
Urinary leak	Y/N
Duration of post operative stay (in days)	…….
Bladder function	
Incontinence (Urge incontinence/stress incontinence)	Y/N
Filling sensation	Y/N
Voiding	
Defecation disturbance Incontinence/Constipation	Y/N
Impotence	Y/N
Phantom limb sensation /pain	Y/N
Reduced by analgesics	Y/N

MORTALITY
Died on ……post operative day
Cause of death

POST OPERATIVE H.P.E

Histology	Grade	IMMUNOHISTOCHEMISTRY

ADJUVANT CHEMOTHERAPY		Y/N
Started on:	Drugs:	No. of cycles

ADJUVANT RADIOTHERAPY Y/N
Started on

EBRT/Brachytherapy/both Total dose No of fractions

FOLLOW UP

Date of visit:
Follow up No.:

POWER OF LOWER LIMB (MRC classification)

MOVEMENT	RIGHT	LEFT
HIP		
Flexion	**/ 5**	**/ 5**
Extension	**/ 5**	**/ 5**
Abduction	**/ 5**	**/ 5**
Adduction	**/ 5**	**/ 5**
External rotation	**/ 5**	**/ 5**
Internal rotation	**/ 5**	**/ 5**
KNEE		
Flexion	**/ 5**	**/ 5**
Extension	**/ 5**	**/ 5**
ANKLE		
Dorsiflexion	**/ 5**	**/ 5**
Plantar flexion	**/ 5**	**/ 5**
TOES		
Dorsiflexion	**/ 5**	**/ 5**
Plantar flexion	**/ 5**	**/ 5**

NEUROLOGIC DEFICIT

Paraplegia Y/N
Paraperesis Y/N
Foot drop Y/N
Sensory loss Y/N

BLADDER FUNCTION

Incontinent/continent
Feel the sense of filling/voiding Y/N

BOWEL HABITS

Incontinence/Constipation

PAIN Y/N

Bearable or Unbearable
Does it interfere with daily activities Y/N

PHANTOM LIMB PAIN/SENSATION Y/N

WALKING
Able to walk Y/N
Walking without support Y/N
Walking with support Y/N
(Walker/crutches/calipers)

GAIT

CLIMB THE STAIRS UP/DOWN Y/N
With support Y/N
Without support Y/N

PERFORM DAILY ROUTINE ACTIVITIES Y/N
(Dressing/bathing etc)
Independently Y/N
Dependent (partly/fully) Y/N

HAS THE Pt RETURNED TO HIS/HER ORIGINAL OCCUPATION? Y/N
If not, why?

EMOTIONAL ASPECT
Worried Y/N
Depressed Y/N
SOCIAL/FAMILY WELL-BEING
Interacts with friends & family members Y/N
Family /friends support the patient Y/N

ONCOLOGICAL OUTCOME

PARAMETERS	1	2	3	4	5	6	7	8	9	10	11	12
Date												

Disease free Y/N												
Recurrence Y/N												
Date of rence												
Site of recurrence												
Local												
Regional												
Distant metastasis Y/N												
Site of metastasis												

FUNCTIONAL OUTCOME ASSESMENT SCORE

S.No	Factor	Normal (4)	Near Normal(3)	Acceptable (2)	Poor (1)

1	**Pain**	**No pain / mild pain**	**-Moderate pain -Tolerable -Does not need analgesics**	**-Severe pain -Reduced by analgesics**	**-Very severe intolerable pain -Not reduced by analgesics -Disturbs sleep/routine activities**
2	**Locomotion**	**Walk without support**	**Walk with support/single crutch**	**Walk with double crutches / walker**	**Not able to walk**
3	**Sensory Deficit**	**Normal**	**Sensory deficit detected on clinical examination**	**-Sensory deficit felt by the pt. -Pt feels the discomfort**	**Trophic ulcer & other secondary changes**
4	**Bladder & Bowel Function**	**Both normal**	**Mild dysfunction**	**Severe dysfunction Acceptable**	**Very severe dysfunction**
5	**Pt 's Acceptance**	**Very good**	**Good**	**Fair**	**Poor**
6	**Ability to return to work (including work at home)**	**Does it independently**	**-Able to do with minimal assistance -modified pattern of work**	**Able to do only with assistance**	**Does'nt do work**

TOTAL SCORE - / 24

RESULT

GOOD SCORE 19 – 24
FAIR SCORE 13 - 18
POOR SCORE 6 - 12

FUNCTIONAL OUTCOME ASSESMENT SCORE

S.No	FACTOR	NORMAL (4)	NEAR NORMAL (3)	ACCEPTABLE (2)	POOR (1)
1	Pain				
2	Locomotion				
3	Sensory Deficit				
4	Bladder & Bowel Function				
5	Pt 's Acceptance				
6	Ability to return to work (including work at home)				

TOTAL SCORE - / 24

RESULT

GOOD SCORE 19 – 24

FAIR SCORE 13 - 18

POOR SCORE 6 - 12

Case	NAME	AGE/ SEX	C.D.No	DIAGNOSIS	SWELLING	PAIN	WEAKNESS	RADIATING PAIN	SENSORY LOSS	BLADDER	BOWEL	MANGEMENT/ SURGERY	D.O.S	APPROACH	TUMOR SITE /*UPPER LIMIT
1	**PARAMA SIVAM**	20/M	4049	Sacral tumor-GCT	+	+	+	+	+	-	-	Total Sacrectomy	13/02/97	Sequentia l A & P	*Body of S1, B/L sacral alae
2	**C.V.LIJU**	19/M	5769/99	Sacral tumor-Chordoma	+	+	-	-	-	-	-	Partial sacrectomy	2/9/1999	Posterior	*S2
3	**NIDHIN GEORGE**	15/F	4961	Sacral tumor-GCT	+	+	-	+	+	-	-	Partial sacrectomy & Curettage	18/03/00	Sequentia l A & P	*Junction between S2,S3
4	**NARAYA NI**	52/F	306/01	Sacral tumor-Chordoma	-	+	-	-	-	-	-	Partial Sacrectomy	23/02/01	Sequentia l A & P	*S3
5	**ASHOK**	35/M	340/02	Sacral tumor-GCT	+	+	-	-	-	+	+	Total Sacrectomy	6/8/2002	Sequentia l A & P	*S1
6	**MUTHUL AXMI**	39/F		Sacral tumor-GCT	-	+	+	-	-	-	-	Partial Sacrectomy	9/8/2003	Sequentia l A&P	*Junction between S2,S3
7	**SURESH**	15/M	6503	Sacral tumor-GCT	-	+	-	-	-	-	-	Partial sacrectomy & Curettage	13/08/03	Sequentia l A & P	*Junction between S2,S3
8	**UMA**	33/F	7177	Sacral tumor-GCT	-	+	-	-	-	-	-	Partial Sacrectomy	30/08/04	Sequentia l A & P	*S2,3,4 Extending to Rt SI joint
9	**UMAKAN TAN**	22/M	7789	Sacral tumor - Myxopapil lary ependymo ma	-	+	-	-	-	-	-	Partial Sacrectomy	20/06/05	Sequentia l A & P	*S2
10	**ABIRAMI**	30/F	Sep-08	Sacral tumor-Chondrobl astoma								Partial Sacrectomy		Posterior	*S3
11	**BEE BEE JOHN**	61/F	383/06	Sacral tumor-Chordoma	+	+	+	+	+	+	+	Total Sacrectomy	10/6/2006	Staged A&P	*S1

12	**THIRUPATHIAH**	29/M	831/06	Sacral tumor-GCT	+	+	+	+	+	+	+	Composite Pelvic exenteration(Total Sacrectomy)+Colostomy	4/8/2006	Staged A&P	*S1
13	**MARY**	20/F	741/06	Sacral tumor-PNET	-	+	+	+	-	-	-	Partial Sacrectomy (Left Hemisacrectomy)	19/07/06	Staged A&P	Left Hemisacrum
14	**DHANASEKAR**	48/M	578/07	Sacral tumor-Chordoma	+	+	+	+	+	+	+	Subtotal Sacrectomy	29/05/07	Staged A&P	*S2
15	**SUNDARI**	50/F	-	Sacral tumor-Chordoma	+	+	+	+	+	+	+	Subtotal Sacrectomy	2007	Staged A&P	*S1
16	**KAIRUNISHA**	65/F	870/08	Sacral tumor-Chordoma	+	+	+	+	-	+	+	Subtotal Sacrectomy	26/08/08	Staged A&P	*S1
17	**RANGANATHAN**	54/M	1682/08	Sacral tumor - chondrosarcoma	+	+	+	+	+	-	-	Subtotal Sacrectomy + Type I Pelvic Resection (Lt)	12/11/2008	Staged A&P	*Left half of S1 body , SI joint , Left Ilium
18	**PARTHEEBAN**	13/M	682/05	Ilium tumor-Hemangioendothelioma	+	+	-	-	-	-	-	Type IV Pelvic Resection Rt → Extra Corporeal Pelvic Bone Irradiation 5oGy- 25Gy/#-2# & →reimplantation	16/09/05	Abdomino Lateral-Localio	Right Ilium tumor infiltrating sacral ala
19	**PERIYASAMY**	22/M	1215/03	Aneurysmal Bone Cyst Rt Ilium	+	+	+	+	+	-	-	Type IV Pelvic Resection Rt + Fibular strut graft	5/1/2004	Abdomino Lateral-Localio	Right Ilium tumor infiltrating sacral ala
20	**RANJITH**	18/M	1029/03	PNET Pelvis	+	+	+	+	+	-	-	NAC (PVCE) 4cycles→Type II + III Pelvic Resection Lt	7/1/2004	Utilitarian pelvic incision	Lt pubic ramus & obturator fossa
21	**PRAKASH**	33/M	266/01	Chondrosarcoma pelvis	+	+	+	+	-	-	-	Type II +III Pelvic Resection Rt +Cadaveric allograft bone transplantation	26/8/04	Utilitarian pelvic incision	periacetabulam
22	**SHRILWILLIAMS**	38/M	1111/04	Chondrosarcoma Rt Ilium	+	+	-	-	-	-	-	Type IV Pelvic Resection Rt	23/11/04	Utilitarian pelvic incision	Rt Ilium, Rt SI Joint, Rt S2-3 sacral foramina

23	**SHEELA**	34/M	833/05	Chondrosarcoma Rt Ilium	+	+	-	-	-	-	-	Type IV Pelvic Resection Rt	4/5/2005	Utilitarian pelvic incision	Rt Ilium, Rt SI Joint, Glut medius/ minimus, iliacus
24	**THENMOZHI**	16/F	438/05	Ewing's sarcoma pelvis	+	+	+	+	-	-	-	NAC-VAC (3) →Type II + III Pelvic Resection Lt	11/5/2005	Utilitarian pelvic incision	Acetabulum & Pubis
25	**ESWARIAH**	16/M	567/06	MPNST Rt Gluteal region	+	+	+	+	-	-	-	Anterior Flap Hemipelvectomy (External)	17/6/06	Utilitarian pelvic incision	-
26	**RANGASAMY**	60/M	1008/07	Chondrosarcoma Rt Ilium	+	+	-	-	-	-	-	Type I+II Pelvic Resection	16.8.07	Utilitarian pelvic incision	Rt Ilium & periacetabulum

Extent of Resection/ *AMPUTATION LEVEL
*lower border of L5 vertebra
*Lower border of body of S2 vertebra & below S2 sacral foramina
*Upper border of S2
*Lower border of body of S2 vertebra & below S2 sacral foramina
*lower border L5 vertebra
*Lower border of body of S2 vertebra & below S2 sacral foramina
*Lower border of body of S2 vertebra & below S2 sacral foramina
*Body of S2 vertebra
*Upper border of S2 vertebra; On the right side → above S2 foramina On the left side → below the S2 foramina
*S2 Lower border
*L5S1 disc

*L5S1 disc
*L5S1 disc & middle of sacrum (left Hemisacrum)
*Lower border of body of S1 vertebra & below S1 sacral foramina
*Upper border of body of S1
*Upper border of Body of S1; right side → above S1 formaina; left side → below S1 foramina
*thru L5S1 disc anteriorly &Lt laterally, including Lt SI joint, Lt Ilium; preserving only Rt half of S1,S2 body
Rt Ilium + part of sacral alae
Rt Ilium + part of sacral alae + ischium
Lt superior & inferior pubic ramus & ramus of ischium + femoral head
Pubis+ periacetabulam
Rt ilium, Rt SI Joint, sacral ala, Sciatic nerve

Ilium, periacetabulum, ala of sacrum, Head & neck of femur, Iliacus, glut medius & minimus, obturator N
acetabulum, pubis, femoral head
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Type I+II Pelvic Resection